

CLAIMS

1. A method of inspecting electrical circuits comprising:
- obtaining first image data relating to at least a part of an electrical circuit;
- obtaining second image data generally corresponding to said part of an electrical circuit, said second image data including at least some image data that is different from said first image data;
- modifying said first image data by employing said second image data thereby to produce an enhanced representation of the electrical circuit; and
- inspecting the enhanced representation for defects.
2. A method of inspecting electrical circuits according to claim 1 and wherein said first image data is in a first spectral range and second image data includes at least some image data in a second spectral range.
3. A method of inspecting electrical circuits according to claim 1 and also comprising:
- enhancing contrast between at least some parts of said second image data representing corresponding parts of the electrical circuit.
4. A method of inspecting electrical circuits according to claim 3 and wherein said enhancing contrast is non-linear.
5. A method of inspecting electrical circuits according to claim 3 and wherein said enhancing contrast includes redefining substrate portions not overlaying conductors in said second image data as opaque substrate portions, thus generally eliminating any distinction between substrate portions which overlay conductors and substrate portions which do not.

6. A method of inspecting electrical circuits according to claim 2 and also comprising:
enhancing contrast between at least some parts of said second image data
representing corresponding parts of the electrical circuit.
7. A method of inspecting electrical circuits according to claim 6 and wherein said
enhancing contrast is non-linear.
8. A method of inspecting electrical circuits according to claim 1 and also comprising:
convolving said first image data with a function.
9. A method of inspecting electrical circuits according to claim 8 and wherein said
function is an approximation of a Laplacian of a Gaussian function.
10. A method of inspecting electrical circuits according to claim 8 and wherein said
modifying is carried out following said convolving.
11. A method of inspecting electrical circuits according to claim 6 and also comprising:
convolving said first image data with a function.
12. A method of inspecting electrical circuits according to claim 11 and wherein said
function is an approximation of a Laplacian of a Gaussian function.
13. A method of inspecting electrical circuits according to claim 11 and wherein said
modifying is carried out following said convolving.

14. A method of inspecting electrical circuits according to claim 1 and also comprising:
determining in said first image data approximate locations of transitions between image regions having distinguishable optical characteristics; and wherein
said modifying comprises removing undesired ones of said transitions.
15. A method of inspecting electrical circuits according to claim 1 and wherein said enhanced representation is a binary representation of said electrical circuit.
16. A method of inspecting electrical circuits according to claim 1 and wherein said enhanced representation is a representation of contours in said electrical circuit, which indicate approximate locations of transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics.
17. A method of inspecting electrical circuits according to claim 1 and wherein said enhanced representation has a spatial resolution that is greater than the spatial resolution of said first and second image data.
18. A method of inspecting electrical circuits according to claim 17 and wherein said enhanced representation has a gray scale whose dynamic range is reduced as compared with the dynamic range of a gray scale of said first and second image data.
19. A method of inspecting electrical circuits according to claim 8 and also comprising:
determining in said first image data approximate locations of transitions between image regions having distinguishable optical characteristics; and wherein
said modifying includes overriding at least part of said convolved first image data.
20. A method of inspecting electrical circuits according to claim 8 and wherein said enhanced representation is a binary representation of said electrical circuit.

21. A method of inspecting electrical circuits according to claim 8 and wherein said enhanced representation is a representation of contours in said electrical circuit, which indicate approximate locations of transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics.

22. A method of inspecting electrical circuits according to claim 8 and wherein said enhanced representation has a spatial resolution that is greater than the spatial resolution of said first and second image data.

23. A method of inspecting electrical circuits according to claim 22 and wherein said enhanced representation has a gray scale whose dynamic range is reduced as compared with the dynamic range of a gray scale of said first and second image data.

24. A method of inspecting electrical circuits according to claim 1 and wherein said first and second images are acquired with at least one imager comprising at least two different types of optical detectors arranged to view at least a portion of said electrical circuit illuminated by at least one illuminator.

25. A method of inspecting electrical circuits according to claim 24 and wherein said first and second images are generally spatially coincidental, and each of said first and second images of is in a different spectral range.

26. A method of inspecting electrical circuits comprising:
obtaining first image data relating to at least part of an electrical circuit in at least a first spectral range;
obtaining second image data relating to at least part of an electrical circuit in at least a second spectral range; and

providing an enhanced contrast representation of the electrical circuit by non-linearly combining said first image data and said second image data .

27. A method of inspecting electrical circuits according to claim 26 and wherein said at least part of an electrical circuit includes first conductors located on a first side of an electrical circuit substrate and second conductors located on a second side of an electrical circuit substrate and wherein said enhanced contrast representation includes information providing enhanced contrast between representations of said first conductors and of said electrical circuit substrate.

28. A method of inspecting electrical circuits according to claim 26 and wherein said enhanced contrast representation exhibits decreased artifacts resulting from a non-opaque characteristic of a substrate.

29. A method of inspecting electrical circuits formed on different surfaces of a non-opaque substrate comprising:

obtaining image data relating to at least part of an electrical circuit, and

enhancing said image data to provide enhanced inspection output information which decreases artifacts resulting from the non-opaque characteristic of the substrate.

30. A method of inspecting electrical circuits according to claim 29 wherein the electrical circuits comprise first conductors on a first side of the substrate and second conductors on a second side of the substrate, and the artifacts include at least part of an image from a substrate portion not having deposited thereon one of said first and second conductors.

31. A method of inspecting electrical circuits comprising:

obtaining first image data relating to at least part of an electrical circuit;

obtaining second image data relating to at least part of an electrical circuit; and

non-linearly combining said first image data and said second image data to form a pseudo image, and supplying said pseudo-image to a high-sure/ low-sure region classifier.

32. A method of inspecting electrical circuits according to claim 31 and wherein said second image data includes image data relating to a plurality of visually distinguishable substrate portions, at least some substrate portions overlaying conductors, and substrate portions not overlaying conductors are redefined in said second image data as substrate portions overlaying conductors.

33. A method of inspecting electrical circuits according to claim 31 and wherein said second image data includes image data relating to a plurality of visually distinguishable substrate portions, at least some substrate portions overlaying conductors, and non-opaque substrate portions are redefined in said second image data as opaque substrate portions.

34. A method of inspecting electrical circuits according to claim 31 and wherein said high-sure/low-sure classifier operates on the pseudo image to produce a high-sure / low-sure image output including at least three regions:

- (i) a low-sure region that to a high degree of confidence represents only substrate;
- (ii) a high-sure region that to a high degree of confidence represents only conductor located on the top surface of said electrical circuit; and
- (iii) a third region which is neither high-sure nor low-sure.

35. A method of inspecting electrical circuits according to claim 34 further comprising:
receiving said first image data and employing said high sure / low sure image to selectively modify an interim image formed from said first image data to produce an enhanced representation of said electrical circuit.

36. A method of inspecting electrical circuits according to claim 35 further comprising:

convolving said first image data with a mathematical function approximating a 2-dimensional Laplacian of a Gaussian function.

37. A method of inspecting electrical circuits according to claim 36 further comprising:
determining in said first image data approximate locations of transitions between image regions having distinguishable optical characteristics.

38. A method of inspecting electrical circuits according to claim 35 and wherein said enhanced representation is a binary representation of said electrical circuit.

39. A method of inspecting electrical circuits according to claim 35 and wherein said enhanced representation is a representation of contours in said electrical circuit, which indicate approximate locations of transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics.

40. A method of inspecting electrical circuits according to claim 39 and wherein said transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics include transitions between substrate and conductors located on a top surface of said electrical circuit, and generally exclude transitions between substrate and other conductors in said electrical circuit.

41. A method of inspecting electrical circuits according to claim 35 further comprising:
analyzing said enhanced representation to provide an indication of defects in said electrical circuit.

42. A method of inspecting electrical circuits according to claim 31 and wherein said first and second image data are acquired with at least two different types of optical detectors arranged to view at least a portion of said electrical circuit illuminated by at least one illuminator.

43. A method of inspecting electrical circuits according to claim 42 and wherein said first and second images of said electrical circuit are generally spatially coincidental, and are each in a different spectral range.

44. A system for inspecting electrical circuits comprising:

a first image data acquisition assembly obtaining first image data relating to at least a part of an electrical circuit;

a second image data acquisition assembly obtaining second image data generally corresponding to said part of said electrical circuit, said second image data including at least some image data that is different from said first image data;

a first image data modifier modifying said first image data by employing said second image data thereby to produce an enhanced representation of the electrical circuit; and

a defect inspector, inspecting the enhanced representation for defects.

45. A system for inspecting electrical circuits according to claim 44 and wherein said first image data is in a first spectral range and second image data includes at least some image data in a second spectral range.

46. A system for inspecting electrical circuits according to claim 44 and also comprising:

a contrast enhancer, enhancing contrast between at least some parts of said second image data representing corresponding parts of the electrical circuit.

47. A system for inspecting electrical circuits according to claim 46 and wherein said contrast enhancer enhances contrast in a non-linear manner.

48. A system for inspecting electrical circuits according to claim 46 and wherein said contrast enhancer is operative to redefine substrate portions not overlaying conductors in said second image data as opaque substrate portions, thus generally eliminating any distinction between substrate portions which overlay conductors and substrate portions which do not.

49. A system for inspecting electrical circuits according to claim 45 and also comprising:
a contrast enhancer, enhancing contrast between at least some parts of said second image data representing corresponding parts of the electrical circuit.

50. A system for inspecting electrical circuits according to claim 49 and wherein said contrast enhancer enhances contrast in a non-linear manner.

51. A system for inspecting electrical circuits according to claim 44 and also comprising:
a convolver, convolving said first image data with a function.

52. A system for inspecting electrical circuits according to claim 51 and wherein said function is an approximation of a Laplacian of a Gaussian function.

53. A system for inspecting electrical circuits according to claim 51 and wherein said modifier operates downstream of said convolver.

54. A system for inspecting electrical circuits according to claim 49 and also comprising:
a convolver, convolving said first image data with a function.

55. A system for inspecting electrical circuits according to claim 54 and wherein said function is an approximation of a Laplacian of a Gaussian function.

56. A system for inspecting electrical circuits according to claim 54 and wherein said modifier operates downstream of said convolver.

57. A system for inspecting electrical circuits according to claim 44 and also comprising:

a transition locator, determining in said first image data approximate locations of transitions between image regions having distinguishable optical characteristics; and wherein

said modifier is operative to remove undesired ones of said transitions.

58. A system for inspecting electrical circuits according to claim 44 and wherein said enhanced representation is a binary representation of said electrical circuit.

59. A system for inspecting electrical circuits according to claim 44 and wherein said enhanced representation is a representation of contours in said electrical circuit, which indicate approximate locations of transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics.

60. A system for inspecting electrical circuits according to claim 44 and wherein said enhanced representation has a spatial resolution that is greater than the spatial resolution of said first and second image data.

61. A system for inspecting electrical circuits according to claim 60 and wherein said enhanced representation has a gray scale whose dynamic range is reduced as compared with the dynamic range of a gray scale of said first and second image data.

62. A system for inspecting electrical circuits according to claim 51 and also comprising:

a transition locator, determining in said first image data approximate locations of transitions between image regions having distinguishable optical characteristics; and wherein

said modifier is operative to override at least part of an output of said convolver.

63. A system for inspecting electrical circuits according to claim 51 and wherein said enhanced representation is a binary representation of said electrical circuit.

64. A system for inspecting electrical circuits according to claim 51 and wherein said enhanced representation is a representation of contours in said electrical circuit, which indicate approximate locations of transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics.

65. A system for inspecting electrical circuits according to claim 51 and wherein said enhanced representation has a spatial resolution that is greater than the spatial resolution of said first and second image data.

66. A system for inspecting electrical circuits according to claim 65 and wherein said enhanced representation has a gray scale whose dynamic range is reduced as compared with the dynamic range of a gray scale of said first and second image data.

67. A system for inspecting electrical circuits according to claim 44 and wherein said first and second data acquisition assemblies comprise at least one illuminator and at least one imager, comprising at least two different types of optical detectors and being arranged to view at least a portion of said electrical circuit illuminated by said at least one illuminator.

68. A system for inspecting electrical circuits according to claim 67 and wherein said imager comprises three types of detectors, each of which is operative to output a generally spatially coincidental image of said electrical circuit in a respective spectral range.

69. A system for inspecting electrical circuits comprising:

- a first image data acquisition assembly, obtaining first image data relating to at least part of an electrical circuit in at least a first spectral range;
- a second image data acquisition assembly obtaining second image data relating to at least part of an electrical circuit in at least a second spectral range; and
- an enhanced contrast representation generator providing an enhanced contrast representation of the electrical circuit by non-linearly combining said first image data and said second image data .

70. A system for inspecting electrical circuits according to claim 69 and wherein said at least part of an electrical circuit includes first conductors located on a first side of an electrical circuit substrate and second conductors located on a second side of an electrical circuit substrate and wherein said enhanced contrast representation includes information providing enhanced contrast between representations of said first conductors and of said electrical circuit substrate.

71. A system for inspecting electrical circuits according to claim 69 and wherein said enhanced contrast representation exhibits decreased artifacts resulting from a non-opaque characteristic of a substrate.

72. A system for inspecting electrical circuits formed on different surfaces of a non-opaque substrate comprising:

- an image data acquisition assembly obtaining image data relating to at least part of an electrical circuit, and

- an image data enhancement assembly, enhancing said image data to provide enhanced inspection output information which decreases artifacts resulting from the non-opaque characteristic of the substrate.

73. A system for inspecting electrical circuits according to claim 72 wherein the electrical circuits comprise first conductors on a first side of the substrate and second conductors on a second side of the substrate, and the artifacts include images of one of said first and second conductors.

74. A system for inspecting electrical circuits comprising:

a first image data acquisition assembly, obtaining first image data relating to at least part of an electrical circuit;

a second image data acquisition assembly obtaining second image data relating to at least part of an electrical circuit; and

a pseudo-image generator non-linearly combining said first image data and said second image data, said pseudo-image generator being operative to supply a pseudo-image of said part of said electrical circuit constructed from said first and second image data to a high-sure/ low-sure region classifier.

75. A system for inspecting electrical circuits according to claim 74 and wherein said second image data includes image data relating to a plurality of visually distinguishable substrate portions, at least some substrate portions overlaying conductors, and wherein said pseudo image generator redefines substrate portions not overlaying conductors in said second image data as substrate portions overlaying conductors.

76. A system for inspecting electrical circuits according to claim 74 and wherein said second image data includes image data relating to a plurality of visually distinguishable substrate portions, at least some substrate portions overlaying conductors, and wherein said pseudo image generator redefines non-opaque substrate portions in said second image data as opaque substrate portions.

77. A system for inspecting electrical circuits according to claim 74 and wherein said high-sure/low-sure classifier operates on the pseudo image to produce a high-sure / low-sure image output including at least three regions:

- (i) a low-sure region that to a high degree of confidence represents only substrate;
- (ii) a high-sure region that to a high degree of confidence represents only conductor located on the top surface of said electrical circuit; and
- (iii) a third region which is neither high-sure nor low-sure.

78. A system for inspecting electrical circuits according to claim 77 further comprising:

a representation generator receiving said first image data, said representation generator including an override circuit in communication with said high-sure/low-sure classifier and operative to employ said high sure / low sure image to selectively modify image data being processed in said representation generator to produce an enhanced representation of said electrical circuit.

79. A system for inspecting electrical circuit according to claim 78 and wherein said representation generator is operative to process said first image data.

80. A system for inspecting electrical circuits according to claim 79 further comprising:

a convolver operative to convolve said first image data with a mathematical function approximating a 2-dimensional Laplacian of a Gaussian function.

81. A system for inspecting electrical circuits according to claim 80 further comprising:

a transition locator operative to determine in said first image data approximate locations of transitions between image regions having distinguishable optical characteristics.

82. A system for inspecting electrical circuits according to claim 78 and wherein said enhanced representation is a binary representation of said electrical circuit.

83. A system for inspecting electrical circuits according to claim 78 and wherein said enhanced representation is a representation of contours in said electrical circuit, which indicate approximate locations of transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics.

84. A system for inspecting electrical circuits according to claim 83 and wherein said transitions between regions in said electrical circuit exhibiting distinguishable optical characteristics include transitions between substrate and conductors located on a top surface of said electrical circuit, and generally exclude transitions between substrate and other conductors in said electrical circuit.

85. A system for inspecting electrical circuits according to claim 78 further comprising:
a defect processor receiving said enhanced representation and being operative to analyze said enhanced representation to provide an indication of defects in said electrical circuit.

86. A system for inspecting electrical circuits according to claim 74 and wherein said first and second data acquisition assemblies comprise at least one illuminator and at least one imager, comprising at least two different types of optical detectors and being arranged to view at least a portion of said electrical circuit illuminated by said at least one illuminator.

87. A system for inspecting electrical circuits according to claim 86 and wherein said imager comprises three types of detectors, each of which is operative to output a generally spatially coincidental image of said electrical circuit in a respective spectral range.